ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 06 | June - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

STUDY TO ASSESS FUNCTIONAL OUTCOME OF INTRA-ARTICULAR FRACTURES OF DISTAL RADIUS TREATED BY LIGAMENTOTAXIS AND PLATE OSTEOSYNTHESIS

Orthopaedics

Dr. Gaurav Rana Postgraduate Resident, Department Of Orthopaedics, Muzaffarnagar Medical College & Hospital, Muzaffarnagar, Uttar Pradesh.

Dr. Nikhil Malik Assistant Professor, Department Of Orthopaedics, Muzaffarnagar Medical College & Hospital, Muzaffarnagar, Uttar Pradesh.

Dr. Lalit Kumar* Professor, Department of Orthopaedics, Muzaffarnagar Medical College & Hospital, Muzaffarnagar, Uttar Pradesh. *Corresponding Author

ABSTRACT

Background: Distal radius fractures are common injuries that can significantly impact wrist function. Various surgical techniques, including open reduction and internal fixation (ORIF) with volar plates and ligamentotaxis using external fixation, are employed to treat these fractures. This study evaluates the functional outcomes and complications associated with these two treatment modalities. **Aim and Objectives:** The primary aim of this study was to assess the functional outcomes of intra-articular distal radius fractures treated by either ligamentotaxis or ORIF with volar buttress plates. The objectives included evaluating the functional outcomes of both techniques and identifying complications arising from each procedure. **Material And Methods:** This hospital-based observational study was conducted at Muzaffarnagar Medical College over 18 months, involving 20 patients aged 20 to 70 years with intra-articular distal radius fractures. Participants were randomly assigned to receive either JESS fixation (30%) or plating (70%). Pre-operative assessments included X-rays for fracture classification, and functional outcomes were evaluated using the Gartland and Werley score at 6, 12, 18, and 24 weeks post-surgery. **Results:** The study found that the plating group exhibited significantly better functional outcomes compared to the JESS fixation group, particularly at 6 and 18 weeks, with mean scores of 4.67 ± 3.51 versus 2 ± 1.73 ($p = 0.05$). Complications were fewer in the plating group, with only one case of malunion, while the JESS fixation group reported instances of superficial infection and stiffness. **Conclusion:** The findings suggest that ORIF with volar plating is a more effective surgical intervention for intra-articular distal radius fractures, leading to better functional recovery and fewer complications compared to ligamentotaxis. This emphasizes the importance of selecting appropriate surgical techniques based on expected outcomes.

KEYWORDS

Distal radius fracture, Open reduction, Internal fixation, Ligamentotaxis, Functional outcome, Complications.

INTRODUCTION

The distal radius (DR) of the forearm frequently sustains fractures. With longer life expectancies, radial fractures are becoming more common, putting more people at risk for these injuries. The elderly and children/adolescents are the main populations affected by distal radial fractures. [1]

Any forearm trauma can cause distal radial fractures. Smith's, Colle's, Torus/Buckle, Greenstick, Die-punch, and isolated radial shaft fractures are examples of isolated DR fractures. [2] Fall on the outstretched hand (FOOSH) injuries are the most common cause of these fractures. Low-energy falls from a standing or seated position are frequently the cause of DR fractures in older adults. [3,4] They frequently fall outside of the conventional named classification and are intra-articular and comminuted fractures. High energy falls that occur on playgrounds or during athletic events are more likely to cause isolated DR fractures in children and adolescents.[5]

Distal radial fractures, either alone or in combination with other fractures and traumas, are extremely common. DR fractures can happen at any age.[6] Children under the age of eighteen and people over fifty are the two most prevalent age groups. [7]

The most common imaging technique for diagnosing DR fractures is X-rays. Radial height, radial inclination, radial shift, volar tilt, ulnar variance, ulnar styloid fracture, and DRUJ widening should all be checked for during an X-ray examination. [1] If X-rays are unclear but the history and physical are very indicative of a fracture, computed tomography (CT) pictures might be required. For fractures that will be fixed in the operating room, particularly intra-articular fractures. [8]

Historically, closed reduction and cast immobilisation have been the main methods used to treat distal radius fractures. However, complications, such as fracture malunion and distal radioulnar joint subluxation or dislocation, are common and can result in subpar functional, radiographic, and cosmetic outcomes. [9]

Because the majority of intra-articular fractures are unstable, surgical intervention is necessary to correct the bone's anatomical alignment and, consequently, its ideal functional capacity.[10,11,12]

Currently, depending on the specific fracture features, both open reduction with internal fixation and indirect (closed) reduction with ligamentotaxis are widely accepted surgical treatment techniques that produce similar results; nevertheless, it is yet to be demonstrated which is superior. [13,14]

Internal fixation is one surgical technique that typically comes after open reduction. In this procedure, the broken bone is exposed to direct view, and the fixation device (like a metal plate) is applied immediately. [15] External fixation (metal pins or screws are inserted into bone, usually via small incisions of the skin, on either side of the fracture are fixed externally, such as by incorporation into a plaster cast or securing into an external fixator frame); percutaneous pinning (this involves the percutaneous (through the skin) insertion of pins and wires); and bone grafts or substitutes (these are inserted into bony defects) are the three other primary surgical treatment strategies that have been documented in the literature. [16]

Internal fixation is accomplished using a variety of methods and tools. Both volar (palm side of the forearm) and dorsal (behind of the forearm) surgical approaches can be used to plat the distal radius. The most popular kind of internal fixation is stabilisation with plates. These can be either non-locking or locking, meaning that the screw heads themselves screw into the plate to function mechanically as a single fixed-angle device. [15] Instead of utilising a single plate for all fracture fragments, fragment-specific fixation uses one or more tiny plates to support specific fracture pieces. [17]

The idea behind ligamentotaxis is that the surrounding soft tissues' stress over a fracture causes the fracture fragments to align. Restoring palmar tilt to the distal radius is not always possible with uniplanar ligamentotaxis achieved by longitudinal traction. In order to achieve appositional and tilting alignment of the distal fragment(s) of a fractured radius, multiplanar ligamentotaxis expands on the idea of uniplanar ligamentotaxis by incorporating hand translation in the dorsal-palmar and radial-ulnar planes.

The current study aims to evaluate the functional outcome of distal radius intra-articular fractures treated by either open reduction and internal fixation using volar buttress plates or ligamentotaxis with external fixation. The problems resulting from ligamentotaxis and plate osteosynthesis will also be evaluated in this study. The optimum course of action for intra-articular distal radius fractures and the

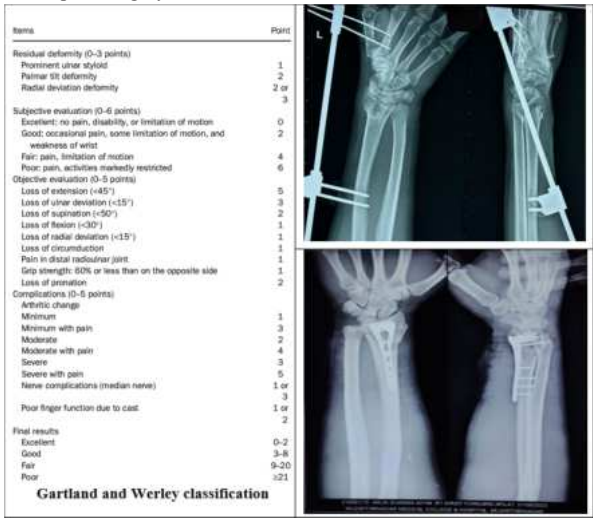
complications of various treatment modalities will be determined.

Aim & Objectives

1. To assess the functional outcomes of open reduction and internal fixation with buttress plates.
2. To assess the functional outcome by ligamentotaxis by external fixation.
3. To assess the complications arising from both the procedures Ligamentotaxis and Plate osteosynthesis.

MATERIAL AND METHODS:

This study aimed to ASSESS FUNCTIONAL OUTCOME OF INTRA-ARTICULAR FRACTURES OF DISTAL RADIUS TREATED BY LIGAMENTOTAXIS AND PLATE OSTEOSYNTHESIS. It was a hospital-based, observational study over 18 months. A total of 20 patients aged 15 to 65 years were taken. Follow up of patients was done at 6, 12, 18 and 24 weeks to assess the functional outcome. Patients with closed intra-articular fracture of distal end radius not associated with any other major fracture with Trauma duration up to 2 weeks. Managed by ligamentotaxis, Dorsal buttress plating and volar buttress plating. Pre-operative assessments included X-rays for fracture classification, and functional outcomes were evaluated using the Gartland and Werley score at 6, 12, 18, and 24 weeks post-surgery.



Items	Point
Residual deformity (0–3 points)	
Prominent ulnar styloid	1
Palmar tilt deformity	2
Radial deviation deformity	2 or 3
Subjective evaluation (0–6 points)	
Excellent: no pain, disability, or limitation of motion	0
Good: occasional pain, some limitation of motion, and weakness of wrist	2
Fair: pain, limitation of motion	4
Poor: pain, activities markedly restricted	6
Objective evaluation (0–5 points)	
Loss of extension (<45°)	5
Loss of ulnar deviation (<15°)	3
Loss of supination (<50°)	2
Loss of flexion (<30°)	1
Loss of radial deviation (<15°)	1
Loss of circumduction	1
Pain in distal radioulnar joint	1
Grip strength: 60% or less than on the opposite side	1
Loss of pronation	2
Complications (0–5 points)	
Arthritic change	
Minimum	1
Minimum with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complications (median nerve)	1 or 3
Poor finger function due to cast	1 or 2
Final results	
Excellent	0–2
Good	3–8
Fair	9–20
Poor	≥21

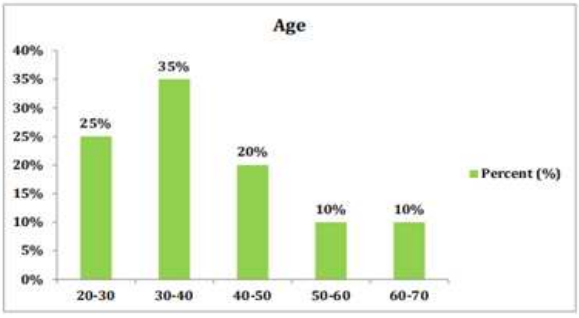
Gartland and Werley classification

Suitable statistical significance tests were used for statistical analysis along with SPSS- 20, Statcalc2 etc.

1. Data was expressed in percentages.
2. Qualitative data was reported as mean and standard deviation.

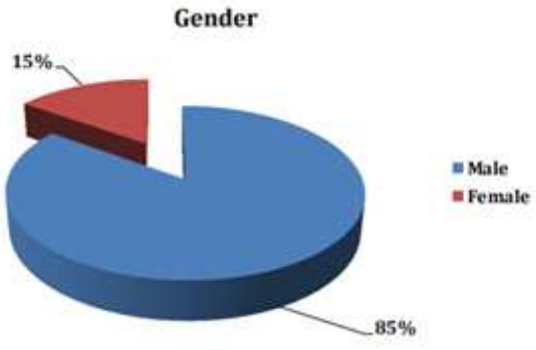
RESULT:

The study included total 20 number of patients treated with ligamentotaxis and plate osteosynthesis. The age distribution of participants ranged from 20 to 70 years. Five age categories were used to group the individuals: 20–30, 30–40, 40–50, 50–60, and 60–70 years. The largest proportion of participants—7 instances, or 35% of the entire population—were in the 30- to 40-year-old age range. Five instances, or 25% of the total, were in the 20–30 age range. Four participants, or 20% of the study population, were in the 40–50 age range. Two instances, or 10% of the total, were reported by the older age groups of 50–60 and 60–70 years. With a mean age of 39.5 years, the results showed a wide range of ages among the participants.



Distribution of study population according to age: (N=20)

The study, which included 20 participants in all, looked at the population's gender distribution. According to this distribution, men made up 85% of the population, while women made up only 15%. The study, which examined the gender distribution of the population, involved a total of twenty participants. According to this breakdown, 85% of people were men and just 15% of people were women.



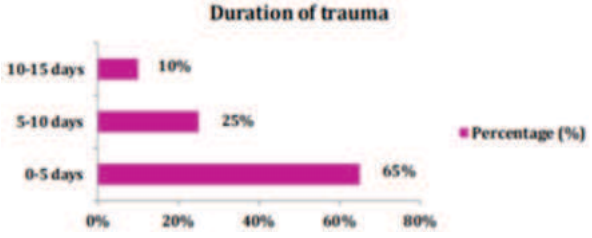
Distribution Of Study Population According To Gender: (N=20)

Twenty instances in all were included in the study, and the distribution of participants based on the mechanism of injury was evaluated. According to the data, falls on an outstretched hand were the most common way of injury, with 12 individuals reporting this type of damage, or 60% of all occurrences. This result suggested that a major cause of the injuries seen in the study population was fall. In contrast, eight participants - or 40% of the total - reported that their injuries were caused by automobile accidents.

Distribution Of Participants According To Mode Of Injury

Twenty instances in all were included in the study, and the distribution of participants based on the length of trauma was examined. The findings showed that the majority of participants—13 people in total—had trauma that lasted 0–5 days, which represented 65% of all instances. This result demonstrated the acute character of the conditions under investigation by indicating that the majority of injuries were recent.

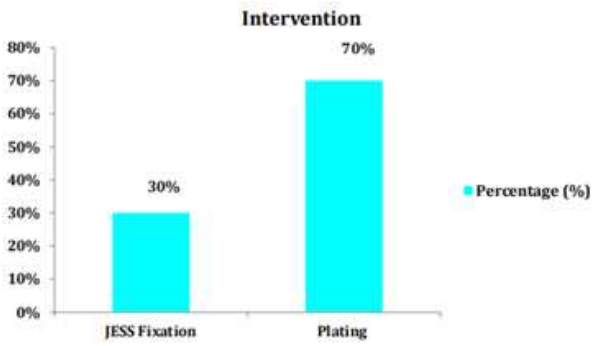
Five participants-or 25% of the entire population—reported experiencing trauma for five to ten days. Just two participants—or 10% of the total—had trauma that lasted 10 to 15 days. The findings highlighted the frequency of recent injuries and showed a distinct trend toward shorter trauma durations among the individuals. Treatment strategies and the level of urgency of care needed for patients presenting with such severe illnesses may be affected by these findings.



Distribution Of Participants According To Duration Of Trauma

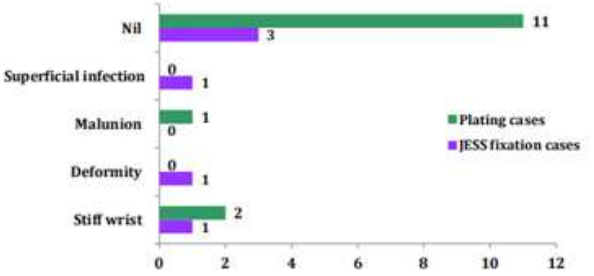
A total of 20 cases were included in the study, and the distribution of participants by of intervention was examined. The findings showed that plating was the most common intervention (14 individuals, or 70% of the population) and that plating was the preferred treatment method among the participants, probably because it was effective in treating the conditions under study. In contrast, 6 participants, or 30% of the

total cases, received JESS fixation as their intervention. The data showed a clear preference for plating over JESS fixation, which may reflect the clinical decision-making processes based on the type and severity of the injuries.



Distribution Of Participants According To Intervention

According to our study's findings, a number of problems were reported by participants who had JESS fixation. In particular, one case of superficial infection, one case of deformity, and one case of stiff wrist were reported. On the other hand, there were generally less issues with the plating group. No incidences of deformity or surface infection were noted in this group, however there was one reported case of malunion. Interestingly, 11 people in the plating group reported no difficulties, while just 3 persons in the JESS fixation group did. Overall, the results indicate that, in comparison to JESS fixation, the plating approach was linked to a decreased frequency of problems. This demonstrates the potential benefits of plating in reducing unfavorable outcomes, which may be a crucial factor for physicians to take into account when choosing surgical treatments for comparable illnesses.



Distribution Of Participants According To Complications: (N=20)

Participants' functional outcomes were evaluated using the Gartland and Werley score at several points in time during the trial. Twenty instances in all were analyzed; six individuals were in the JESS fixation group and fourteen were in the plating group.

One participant in the plating group received a score of 5–10 at the 6-week period, however none of the JESS fixation group members did. Three members of the plating group and five members of the JESS fixation group scored in the 15-20 range, while three members of the plating group and eight members of the JESS fixation group were recorded in the 10-15 range. The plating group's mean score was 4.67 ± 3.51, while the JESS fixation group's was 2 ± 1.73.

Three members of the JESS fixation group and eight members of the plating group both had scores in the 5–10 range at 12 weeks. Only one participant from the JESS fixation group scored in the 15-20 range, compared to two from the plating group and six from the JESS fixation group. The plating group's mean score was 4.67 ± 4.16, whereas the JESS fixation group's was 2 ± 1.

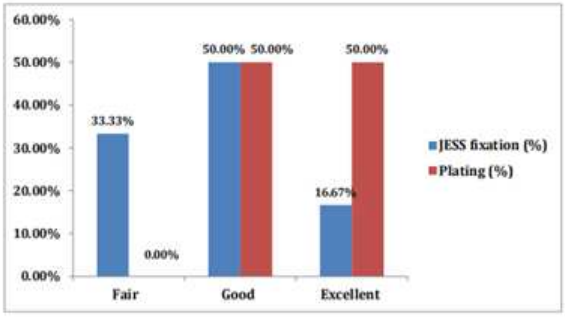
Five members in the plating group received a score between 0 and 5 on the 18-week assessment, compared to one member of the JESS fixation group. Four members of the JESS fixation group and eight members of the plating group were recorded in the 5–10 range, while one member of the plating group and one member of the JESS fixation group were reported in the 10-15 range. The plating group maintained a mean score of 4.67 ± 3.51, while the JESS fixation group's mean score stayed at 2 ± 1.73.

Finally, at 24 weeks, 12 people in the plating group had a score between 0 and 5, compared to 4 participants in the JESS fixation group. Two participants from the plating group and two from the JESS fixation group were reported in the 5–10 range; none of the subjects in either group scored in the 10-15 range. The plating group's mean score was 4.67 ± 4.63, whereas the JESS fixation group's was 2 ± 2.

Functional Outcome	JESS Fixation (n=06)	Plating (n=14)
At 6 weeks		
5-10	00	01
10-15	03	05
15-20	03	08
Mean +- S.D.	**2 ± 1.73**	**4.67 ± 3.51**
At 12 weeks		
5-10	03	08
10-15	02	06
15-20	01	00
Mean +- S.D.	**2 ± 1**	**4.67 ± 4.16**
At 18 weeks		
0-5	01	05
5-10	04	08
10-15	01	01
Mean +- S.D.	**2 ± 1.73**	**4.67 ± 3.51**
At 24 weeks		
0-5	04	12
5-10	02	02
10-15	00	00
Mean +- S.D.	**2 ±2**	**4.67 ± 4.63**

Distribution Of Participants According To Functional Outcome On The Basis Of Gartland And Werley Score: (N=20)

In the study, the outcomes were categorized into **fair**, **good**, and **excellent** results for both the **JESS fixation** and **plating** groups. Among the participants who underwent **JESS fixation**, **2 cases** (33.33%) were classified as having a **fair** outcome, while **3 cases** (50%) achieved a **good** outcome, and **1 case** (16.67%) was rated as **excellent**. In contrast, the **plating group** demonstrated a different distribution of results. Notably, there were **no cases** (0%) classified as **fair**. The **good** outcome was achieved by **7 participants** (50%), and **7 participants** (50%) also attained an **excellent** outcome.



Overall, the findings indicate that while the **JESS fixation** group had a mix of outcomes, the **plating group** showed a stronger performance with a higher proportion of participants achieving **good** and **excellent** results. This suggests that **plating** may be a more effective intervention for achieving favorable outcomes in the studied population, reinforcing the importance of selecting appropriate surgical techniques based on expected results.

DISCUSSION:

The current investigation was carried out by the Department of Orthopaedics. Twenty patients with intra-articular distal radius fractures, aged 20 to 70, were enrolled in the current study with

informed consent and approval from the Institutional Ethical Committee.

Age

—Our study reported a mean age of 39.5 years. The 30-40 age group had the highest representation with 7 cases (35%), followed by the 20-30 group with 5 cases (25%). The 40-50 age group included 4 participants (20%), while the 50-60 and 60-70 groups each had 2 cases (10%). **Chung KC et al (2001)** reported that most affected age group was 5 to 14 years of age (26%). [18] Court-Brown & Caesar (2006) found that wrist fractures were more common in working-age adults due to high-energy trauma. [19] **Brogren et al. (2007)** included women of 50-75 years of age, initially treated with cast or external fixation, were examined 1 year after distal radial fracture and then reevaluated after a mean of 3 (range, 2-4) years. They reported a high incidence of distal radius fractures in the 35-50 age group, often due to fall related injuries. [20] **Baron et al. (2018)** concluded that fractures distal to the elbow or knee, however, had, at most, modest increases in incidence with age over 65 years.‖ [21]

Mode Of Injury

According to this survey, falls on an outstretched hand account for 60% of injuries, with driving accidents coming in second at 40%. According to research by **MacIntyre et al. (2015),** playing sports and car crashes are the leading causes of DRF in children and young adults. Conversely, low-energy trauma from a fall from a standing height is the most frequent mechanism of damage in older persons. Having a compensated injury, being older, being female, having poor bone healing (or an accompanying ulnar styloid fracture), and having a lower socioeconomic position are all linked to worse health outcomes. [22] A study by **Melton et al. (1998)** that looked at the 50-year period from 1945 to 1994 found that there was no secular increase in fractures from moderate trauma (roughly osteoporosis), but there was a statistically significant increase in distal forearm fractures from severe trauma in both men and women ($p < 0.001$). The overall doubling of age-adjusted forearm fracture incidence in men between 1945 and 1994 was statistically significant ($p < 0.001$) because fractures attributed to severe trauma accounted for a larger percentage of the total in men (52%) than in women (21%). However, the 7% increase in age-adjusted rates among women was not statistically significant ($p = 0.90$).[23]

Duration of Trauma

According to our study's findings, 13 participants—representing 65% of the total—had trauma that lasted anywhere from 0 to 5 days. Furthermore, only two participants—or 10% of the total—had trauma that lasted between 10 and 15 days, whereas five participants—or 25% of the population—reported trauma that lasted between 5 and 10 days. In order to avoid complications, **Handoll & Madhok (2003)** discovered that the majority of wrist fracture cases were treated within a week. [24]

Intervention

According to the current study, 30% of individuals had JESS fixation and 70% had plating. The effectiveness of plating and JESS fixation for distal radius fractures has been examined in a number of studies. According to **Chen et al. (2011),** plating offers better functional results with a greater range of motion and fewer complications than external fixation. [25] According to Shukla R et al., using the Green and O'Brien scores for range of motion (22.0 ± 4.77 vs 19.89 ± 5.05), grip strength (19.91 ± 5.4 vs 16.89 ± 4.4), and final outcome (87.36 ± 11.62 vs 81.55 ± 11.32), they found that external fixation performed noticeably better than volar locking plates one year after surgery. There was no difference in the two patient groups' levels of activity or discomfort.

Patients under 50 years old who received external fixation had outstanding outcomes, with a final score of 91.57 ± 9.01 at the one-year follow-up. After a year after surgery, external fixation was found to be superior than volar-locked plating. [26] The results on addiction and fracture risk align with research showing how alcohol and smoking affect bone health. The management and healing of fractures are greatly impacted by the presence of chronic conditions such as diabetes and hypertension. Numerous investigations have shown that plating is preferable to JESS fixation, which supports the preference for plating in surgical therapy.

Functional Outcome on the Basis of Gartland and Werley Score

Functional results were evaluated at 6, 12, 18, and 24 weeks in this trial, and the plating group recovered more quickly than the JESS fixation group. A total of 20 cases—six in the JESS group and fourteen in the plating group—were used in the study to compare the functional outcomes of participants who had JESS fixation with those who underwent plating using the Gartland and Werley score at different time intervals. Plating may be a more successful strategy for attaining positive recovery in this population, as the results repeatedly shown that participants who got plating had considerably higher functional outcomes than those who had JESS fixation. According to **Chen et al. (2011),** plating offers a greater range of motion, less problems, and a better functional recovery than external fixation. [25] According to **Williksen JH et al.,** the EF group's operating time was 77 minutes, whereas the VLP group's was 88 minutes. Patients with VLPs showed improved supination (89°vs. 85°), less radial shortening (+1.4 mm vs. +2.2 mm), and a higher Mayo wrist score (90 vs. 85) after 52 weeks. In the EF group, there were more patients (16 vs. 6) who experienced pain over the ulnar styloid. Patients with VLPs had reduced ulnar shortening (+1.1 mm vs. +2.8 mm) and improved supination (90° vs. 76°) for AO type C2/C3. The EF group experienced a 30% complication rate, while the VLP group experienced a 29% rate. Complications led to the removal of eight (15%) plates. There was no discernible difference in the groups' QuickDASH scores. Their findings supported the use of VLPs for the treatment of unstable distal radius fractures, despite the fact that they did not identify a significant difference between the groups for the QuickDASH score. [27]

Studies	Excellent	Good	Fair	Poor
Salama AM et al (2020)	50%	33.3%	16.7%	-
Singh PK et al (2021)	48%	34%	12%	6%
Sadalagi PS et al (2023)	46.7%	40%	10%	3.3%
Present study	40%	50%	10%	-

Complications

The study revealed that participants who underwent JESS fixation experienced several complications, including 1 case each of stiff wrist, deformity, and superficial infection. In contrast, the plating group had fewer complications, with only 1 case of malunion and no deformities or infections.

Additionally, 3 participants in the JESS group reported no complications, compared to 11 in the plating group. Overall, these findings indicate that plating is associated with a lower incidence of complications than JESS fixation, suggesting it may be a more favourable surgical option. **Mellstrand Navarro C et al (2016)** that the total rate of complications was equal for both groups. [28] **Rozental TD et al (2009)** found that eight complications occurred, two in the open reduction and internal fixation group and six in the closed reduction and pin fixation group.

CONCLUSION

The study, conducted at Muzaffarnagar Medical College & Hospital, involved 20 patients ranging in age from 20 to 70. It looked at the outcomes of two surgical techniques for wrist injuries: JESS fixation and plating. The results showed that there was a significant age distribution, that men made up the bulk of participants (85%), and that the most common symptoms they brought to the table were edema and wrist pain. The most common source of harm (60%) was a fall onto an outstretched hand.

The findings demonstrated that participants who had plating had significantly better functional outcomes than those who got JESS fixation at various time intervals, particularly at 6 and 18 weeks, with p-values showing statistical significance. Furthermore, the plating group experienced less problems, indicating its advantages over JESS fixing.

The study compares the outcomes of JESS fixation and plating, revealing that the JESS fixation group had a mix of results with 33.33% classified as fair, while 50% achieved a good outcome and 16.67% an excellent outcome. In contrast, the plating group demonstrated stronger performance with no fair outcomes, 50% achieving good

results, and 50% rated as excellent. These findings suggest that plating may be a more effective surgical intervention, highlighting the importance of selecting appropriate techniques based on expected outcomes.

According to the study's findings, plating is a more effective surgical technique for wrist injuries, leading to a greater functional recovery and fewer After effects. These findings demonstrate how important it is to select the most effective surgical techniques based on expected outcomes in order to optimize patient care in orthopaedic practices.

REFERENCES

1. Corsino CB, Reeves RA, Sieg RN. Distal Radius Fractures. [Updated 2023 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK536916/
2. Caldwell RA, Shorten PL, Morrell NT. Common Upper Extremity Fracture Eponyms: A Look Into What They Really Mean. J Hand Surg Am. 2019 Apr;44(4):331-334. [PubMed] [Reference list]
3. Meena S, Sharma P, Sambharia AK, Dawar A. Fractures of distal radius: an overview. J Family Med Prim Care. 2014 Oct-Dec;3(4):325-32. [PMC free article] [PubMed] [Reference list]
4. Karl JW, Olson PR, Rosenwasser MP. The Epidemiology of Upper Extremity Fractures in the United States, 2009. J Orthop Trauma. 2015 Aug;29(8):e242-4. [PubMed] [Reference list]
5. Naranje SM, Erali RA, Warner WC, Sawyer JR, Kelly DM. Epidemiology of Pediatric Fractures Presenting to Emergency Departments in the United States. J Pediatr Orthop. 2016 Jun;36(4):e45-8. [PubMed] [Reference list]
6. MacDermid JC, Richards RS, Roth JH. Distal radius fracture: a prospective outcome study of 275 patients. Journal of Hand Therapy. 2001 Apr 1;14(2):154-69.
7. Jerrhag D, Englund M, Karlsson MK, Rosengren BE. Epidemiology and time trends of distal forearm fractures in adults - a study of 11.2 million person-years in Sweden. BMC Musculoskelet Disord. 2017 Jun 02;18(1):240. [PMC free article] [PubMed] [Reference list]
8. Mauck BM, Swigler CW. Evidence-Based Review of Distal Radius Fractures. Orthop Clin North Am. 2018 Apr;49(2):211-222. [PubMed] [Reference list]
9. Bacorn RW, Kurtzke JF: Colles' Fracture: A study of two thousand cases from the New York states Compensation Board. J Bone Joint Surg 1953; 35A: 643-658.
10. Jeudy J, Steiger V, Boyer P, Cronier P, Bizot P, Massin P. Treatment of complex fractures of the distal radius: a prospective randomised comparison of external fixation 'versus' locked volar plating. Injury. 2012 Feb 1;43(2):174-9.
11. Kapoor H, Agarwal A, Dhaon BK. Displaced intra-articular fractures of distal radius: a comparative evaluation of results following closed reduction, external fixation and open reduction with internal fixation. Injury. 2000 Mar 1;31(2):75 9.
12. Rogachefsky RA, Lipson SR, Applegate B, Ouellette EA, Savenor AM, McAuliffe JA. Treatment of severely comminuted intra-articular fractures of the distal end of the radius by open reduction and combined internal and external fixation. JBJS. 2001 Apr 1;83(4):509.
13. Esposito J, Schemitsch EH, Saccone M, Sternheim A, Kuzyk PR. External fixation versus open reduction with plate fixation for distal radius fractures: a meta-analysis of randomised controlled trials. Injury. 2013 Apr 1;44(4):409 16.
14. Axelrod TS, McMurtry RY. Open reduction and internal fixation of comminuted, intraarticular fractures of the distal radius. Journal of Hand Surgery. 1990 Jan 1;15(1):1-1.
15. Hoare CP, Dickson DR, Armstrong DJ, Nuttall D, Watts AC. Internal fixation for treating distal radius fractures in adults. Cochrane Database Syst Rev. 2017 Sep 26;2017(9):CD011213. doi: 10.1002/14651858.CD011213.pub2. PMCID: PMC6483690.
16. Fernandez DL, Jupiter JB. Fractures of the Distal Radius. Springer Verlag, 1995. [Google Scholar]
17. Gavaskar AS, Muthukumar S, Chowdary N. Fragment-specific fixation for complex intra-articular fractures of the distal radius: results of a prospective single-centre trial. *Journal of Hand Surgery - European volume* 2012;37(8):765-71. [PubMed] [Google Scholar]
18. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg Am. 2001 Sep;26(5):908-15. doi: 10.1053/jhsu.2001.26322. PMID: 11561245.
19. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury. 2006 Aug;37(8):691-7. doi: 10.1016/j.injury.2006.04.130. Epub 2006 Jun 30. PMID: 16814787.
20. Brogren E, Hofer M, Petranek M, Dahlin LB, Atroshi I. Fractures of the distal radius in women aged 50 to 75 years: natural course of patient-reported outcome, wrist motion and grip strength between 1 year and 2-4 years after fracture. J Hand Surg Eur Vol. 2011 Sep;36(7):568-76. doi: 10.1177/1753193411409317. Epub 2011 May 18. PMID: 21593069.
21. Baron JA, Karagas M, Barrett J, Kniffin W, Malenka D, Mayor M, Keller RB. Basic epidemiology of fractures of the upper and lower limb among Americans over 65 years of age. Epidemiology. 1996 Nov;7(6):612-8. doi: 10.1097/00001648-199611000-00008. PMID: 8899387.
22. MacIntyre NJ, Dewan N. Epidemiology of distal radius fractures and factors predicting risk and prognosis. J Hand Ther. 2016 Apr-Jun;29(2):136-45. doi: 10.1016/j.jht.2016.03.003. PMID: 27264899.
23. Melton LJ 3rd, Amadio PC, Crowson CS, O'Fallon WM. Long-term trends in the incidence of distal forearm fractures. Osteoporos Int. 1998;8(4):341-8. doi: 10.1007/s001980050073. PMID: 10024904.
24. Handoll HH, Madhok R. Conservative interventions for treating distal radial fractures in adults. Cochrane Database Syst Rev. 2003;(2):CD000314. doi: 10.1002/14651858.CD000314. PMID: 12804395.
25. Chen NC, Jupiter JB. Management of distal radius fractures. J Bone Joint Surg Am. 2011;93(11):1012-1024.
26. Shukla R, Jain RK, Sharma NK, Kumar R. External fixation versus volar locking plate for displaced intra-articular distal radius fractures: a prospective randomized comparative study of the functional outcomes. J Orthop Traumatol. 2014 Dec;15(4):265-70. doi: 10.1007/s10195-014-0317-8. Epub 2014 Sep 6. PMID: 25193416; PMCID: PMC4244555.
27. Williksen JH, Frihagen F, Hellund JC, Kvernmo HD, Husby T. Volar locking plates versus external fixation and adjuvant pin fixation in unstable distal radius fractures: a randomized, controlled study. J Hand Surg Am. 2013 Aug;38(8):1469-76. doi: 10.1016/j.jhsa.2013.04.039. PMID: 23890493.
28. Mellstrand Navarro C, Ahrengart L, Törnqvist H, Ponzer S. Volar Locking Plate or External Fixation With Optional Addition of K-Wires for Dorsally Displaced Distal Radius Fractures: A Randomized Controlled Study. J Orthop Trauma. 2016 Apr;30(4):217-24. doi: 10.1097/BOT.0000000000000519. PMID: 26709818.